Aggregate Program Activities in 2004

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Introduction

The primary focus of the Aggregate Program is evaluation of the mineral aggregate resource in Nova Scotia. This includes (1) bedrock that can be used for the production of crushed stone and (2) surficial deposits consisting of glacial sand and gravel. Using methods such as field mapping, air photo interpretation, laboratory testing and thin section petrography, data are continually being collected and processed to gain a better understanding of the resource. The long-term goal is the preparation of a publicly accessible database which can be used to identify aggregate potential for resource development purposes throughout the province.

Research conducted under this program also has an important educational value. This reflects the fundamental role that aggregate plays in modern societies and the accelerating pressure that the resource faces from over-use and development access problems. In effect, this information permits a glimpse into the future of the resource. This program provides an opportunity to inform stakeholders (i.e. government, industry and tax payers) of resource concerns and potential solutions that could be implemented to mitigate current trends. Protecting this valuable resource and ensuring its responsible use should be a priority for everyone in society.

In addition to the ongoing geoscientific research, the Aggregate Program provides assistance to a broad range of clients including the aggregate industry, consulting firms, government agencies and private citizens. Client needs can vary from requests for geotechnical data, to environmental issues, to aggregate product information. A final important component of the program is the constant evaluation of the industry and markets to determine if new development potential may exist for Nova Scotia's aggregate resource.

The focus of the Aggregate Program during 2004 was the Annapolis Valley Project and the Western Halifax Regional Municipality (HRM) Project (Fig. 1). A description of activities conducted during the year, and a discussion of the current status of these projects is provided below.

Annapolis Valley Project

A major, continuing project conducted in recent years is a regional assessment of the aggregate resource in the Annapolis Valley and adjacent areas. The focus of the research is a field study covering Hants, Kings, Annapolis, Digby and Yarmouth counties (Fig. 1). Through air photo interpretation, field investigation and a sampling program, the area is being evaluated for its bedrock (crushed stone) and surficial (sand and gravel) aggregate potential. The field component of the study also provided an opportunity to examine the region for other industrial minerals with development potential, including clay deposits and specialty stone products. The specialty materials included aggregate for landscaping, armourstone, dimension stone and other manufactured rock products.

Project Status

The 2004 field season saw the completion of the fieldwork component of the project. This included work on Digby Neck, the Fourth Lake area, Cambridge, Leminster and Benjamins Mill. During the same period, Paul Barker and the Geoscience Information Services Section completed the digital base maps which will be used to construct the 1:50 000 aggregate resource maps. This important aspect of the project consisted of compiling pre-existing bedrock and surficial geological maps for the five counties. Finally, the large backlog of bedrock and gravel samples in storage were analyzed for aggregate properties by Jacques Whitford Limited.

Overview of Project Results

Although a large amount of data entry and analysis

Prime, G. A. 2005: *in* Mineral Resources Branch, Report of Activities 2004; Nova Scotia Department of Natural Resources, Report ME 2005-1, p. 93-99.

remains to be completed in 2005, the aggregate potential for the region can be discussed in general terms. This discussion will primarily focus on the geotechnical aspects that affect rock quality or the suitability of a deposit for resource extraction. Other land-use or environmental issues that could affect resource development were documented, but are beyond the scope of this discussion. They will be presented in the digital database and final report.

Bedrock Potential

The primary bedrock aggregate potential in the region can be found in the granitic rocks (the South Mountain Batholith, the Brenton Pluton and the Wedgeport Pluton), the North Mountain basalt, quartzite (metagreywacke) of the Goldenville Formation, some of the Silurian volcanic rocks and quartzite of the White Rock Formation. This assessment generally reflects the hardness and durability of many of the rocks found in these bedrock units.

The best aggregate potential in the granitic rocks of the South Mountain Batholith (SMB) is generally found in fine- to medium-grained stone. This is attributed to the low frequency or absence of microfractures which normally cause stone weakness and make the rock prone to water entry and weathering. There is also an absence of large feldspar crystals which are common in the coarse-grained rock. Although these large crystals or grains are hard, they tend to be brittle and create a mechanical weakness in rocks where they are present.

Another factor favouring fine-grained rock of the SMB is a general absence of near-surface weathering. When highly fractured, altered granitic bedrock is exposed to surface conditions such as water infiltration and freeze-thaw cycles, the bedrock fragments *in situ* over time. This weathering of the bedrock surface creates friable, disaggregated rock which can be several metres in thickness. (This granitic bedrock is fragmented to the point that it can be ripped with an excavator.) The problem is quite common in the coarse-grained granitic rocks, which the author speculates is caused by a combination of abundant micro-fractures and pervasively altered bedrock. These weathered zones are not only unacceptable for construction aggregate but would have to be treated as overburden, resulting in costly removal of the materials to get at the ‘solid’ rock beneath. The characteristics of the bedrock that lead to weathering, however, probably are present in the rock below the weathered zone, suggesting that this bedrock would probably be unacceptable for construction aggregate as well. These weathered zones are quite common in the SMB rocks.

The Brenton Pluton near Yarmouth, which is distinct from the SMB, also appears to make high quality construction aggregate. This unit is the primary source of stone in the Yarmouth area. The rock is deformed, with a faint schistose fabric. It appears to be quite ‘fresh’ and unaltered, with little evidence of surface weathering. Aggregate test results for the rock samples collected in this study have not been assessed at the time of this writing. An assessment of the Brenton Pluton will be provided in the final report for the project.

The Wedgeport Pluton consists of comparatively hard, unaltered rock, suggesting that it may be suitable for construction aggregate. One potential drawback is the relatively coarse-grained nature of the stone. An assessment of this intrusive for aggregate potential cannot be completed until test results for the rock samples have been evaluated.

The Jurassic basalt of the North Mountain can make excellent aggregate, but this depends on the composition of the rock. This 400 m thick package of tholeiitic volcanic rocks has been subdivided by Kontak and Dostal (2002) into upper-, middle- and lower-flow units. The lower and upper units are each massive, single flow units characterized by columnar-jointed rock. They are separated by the middle unit which consists of a complex sequence of amygdaloidal flows. The amygdular zones occur in the upper part of these lava flows, the result of gas bubbles rising toward the surface following deposition of these molten materials. Subsequently the vesicles were infilled with zeolites.

The rocks in the upper- and lower-flow units have been used extensively for construction aggregate. This reflects the solid nature of these massive homogeneous rocks. The middle-flow unit, on the other hand, is less likely to produce good aggregate. This reflects the friable nature of the amygdaloidal units. Similar to the granitic rocks, near-surface weathered zones in the basalts (possibly present in all three flow units) should be

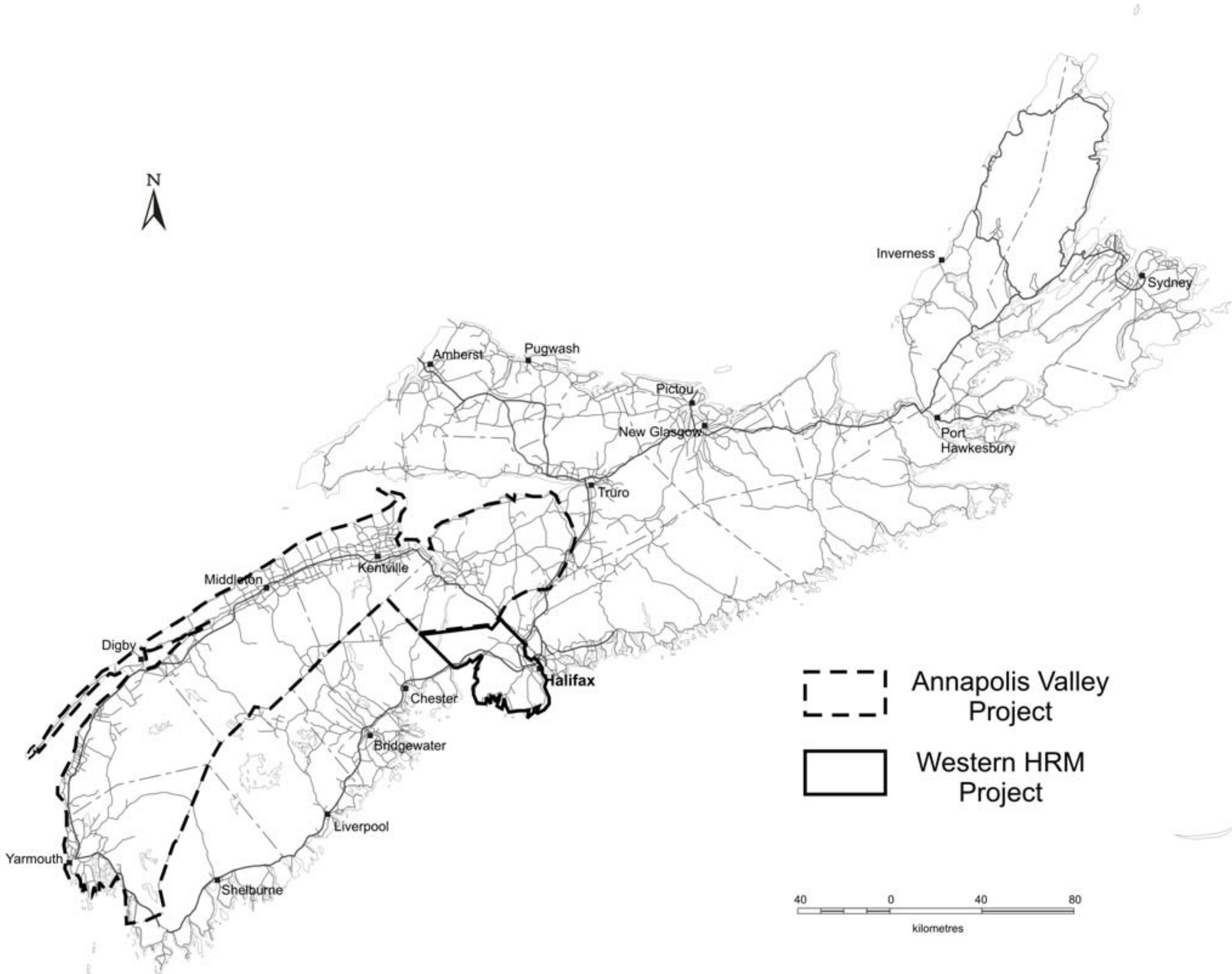

Figure 1. Location map showing general project areas of the Aggregate Program in 2004.

avoided due to weakness in the stone. The areas containing friable rock (including the zeolitic and weathered zones), which is substandard for the production of construction aggregate, are easily identified in the field as shallow 'pits' where the bedrock has been ripped with a bulldozer or excavator. The middle-flow unit commonly is expressed as topographic lows due to preferential weathering associated with glaciation. It generally occurs as the central area on top of the North Mountain and runs parallel to this highland's northeast-southwest trend along its entire length. Although current geological maps do not show these important unit subdivisions, it is anticipated that they can be delineated through air photo interpretation and will be identified on the final aggregate resource maps.

The quartzite of the Goldenville Formation of the Meguma Group has historically been the aggregate of choice in the western half of mainland Nova Scotia. This largely reflects the durability of this rock and its widespread presence in the region. Within this formation, however, there is the common presence of less desirable rocks such as slate (metamorphosed shale) and argillite (metamorphosed siltstone). The layering associated with these fine-grained rocks commonly makes them soft, friable and prone to water entry as aggregate particles. The best quality quartzites for construction aggregate are those deposits that contain a minimum of fine-grained, foliated rock. They are generally recognizable as stacked sequences of thick beds of quartzite with minimal interbeds of fine-grained rock. As a general rule the individual beds of quartzite within the package should be metres in thickness. The author speculates that, due to depositional conditions at the time, areas of thinner beds ($\leq$1 m) are more likely to contain higher amounts of slate or siltstone interbeds separating the quartzite units. This opinion remains to be verified by geoscientists who are more knowledgeable about the sedimentological characteristics of the Meguma Group rocks.

Areas where the Goldenville Formation quartzites are near contacts with the Halifax Formation slates (informally referred to as the 'transition zone') should be avoided or approached with caution when looking for a quarry site. These areas, which are defined by interlayering of coarse-grained (quartzite) and fine-grained rock (slate and argillite), usually contain an abundance of deleterious slate and siltstone. There is also a higher probability of encountering acid-generating minerals (sulphides) and metals, which can be damaging to human health and the environment (e.g. arsenic and lead).

Metamorphosed quartzites of the Silurian White Rock Formation have been used for construction aggregate. Although not a lot of work was done on this rock group as part of this study, the potential of stone appears to largely depend on the depositional conditions of the rock. Similar to the Goldenville Formation, the best areas for quarrying host thick, massive quartzites with minimal fine-grained sedimentary rocks. Samples have been collected and are currently being tested for aggregate quality.

Silurian and Devonian volcanic rocks also appear to have good potential for construction grade aggregate. This generally reflects the hardness and durability of the rock. Although little work has been done on these rocks as part of this study, the best areas for exploration would be volcanic packages where there are minimal interbedded softer sedimentary rocks such as slate or siltstone. Samples have been collected and are currently being processed for aggregate tests.

Surficial Potential

Surficial deposits that can be used for aggregate primarily consist of glacial sand and gravel. These materials are found throughout the region as ice-contact, proglacial and glaciomarine sediments deposited during the final stages of Pleistocene glaciation. Ice-contact stratified drift deposits formed in meltwater channels on, in, or under the ice during stages of ice melting and glacial retreat. They are usually mound-shaped and include eskers, kames and kame deltas. Proglacial deposits formed at the front of the melting ice in shallow, high energy streams. These outwash plain deposits are characterized by a planar surface and are usually aerially extensive. The glaciomarine deposits were produced during the late stages of ice melting or following deglaciation as coarse-grained Gilbert-type deltas or raised beaches. The deltaic deposits formed where outwash streams abruptly dumped their sediment load in standing water along the marine shoreline. Raised beaches formed when sea levels were higher relative to the land at the time due to depressed land associated with the former ice loading. When the land eventually rebounded, the sand and gravel beaches were raised above the modern shoreline. This effect only occurs in those shoreline areas where the land has rebounded faster than sea level has risen.

The value of glacial deposits as sources of sand and gravel is a reflection of their quality, size and location. Most of the gravel in the region would be classified by the author as moderate in terms of quality. This reflects the lithological composition of the clasts that have been produced by erosion of the source rock. Although the stone that is incorporated into glacial ice during its advance covers the spectrum of rock types found in the underlying bedrock in the area, the process is not random. This is because glacial erosion tends to preferentially wear and break down bedrock surfaces that are mechanically weakened due to their lithological composition, structural deformation or the presence of alteration minerals. Rocks in the region that fit into these categories include slate, unmetamorphosed shale and sandstone, weathered granite, weathered basalt, zeolitic basalt and rock in shear zones. Although most gravel contains a significant amount of durable rock, the presence of unsound or deleterious rock in comparatively small proportions can negatively impact the overall quality of the materials. Much of the gravel overlying the Triassic redbeds on the Annapolis Valley floor, the basalts of the North Mountain and the granites of the South Mountain, would not pass specifications for most high quality construction aggregate products. However, these materials are (and will continue to be) used for local markets in applications where aggregate quality is less significant (e.g. surfacing driveways, back fill, gravel road maintenance).

A small proportion of gravel deposits contain pyritic slate clasts in unacceptable amounts. These sulphides can have a negative impact on the environment because of the potential of increasing acidity in streams. Gravel containing pyritic slate usually occurs near (or overlying) slate bedrock.

Although new sand and gravel deposits were identified as part of this study, the vast majority of the deposits in the region are well known to the aggregate industry. This reflects decades of use by the industry and the ongoing discovery of deposits by land owners during land tillage or excavations for other purposes. The last twenty to thirty years have seen the construction of hundreds of new access roads throughout the region for purposes such as forestry management and cottage developments. As a result, the hundreds of kilometres of roads that criss-cross the region have intersected a large number of sand and gravel deposits. The heavy equipment operators who make the roads are extremely adept at identifying these glacial sediments. Modern forest harvesting practices, such as clear cutting, have also visually exposed many of the mound deposits to those who understand the significance of these land forms. Undoubtedly, other deposits will be discovered in the future; however, many of them will remain hidden for a long time because they are covered with unsorted till. Research done in Hants County by Dr. Ralph Stea of NSDNR has identified sand and gravel deposits below substantial thicknesses of till. The author has also recorded several sand and gravel deposits overlain by till in the region.

Another important indicator or predictor of the presence of sand and gravel deposits is regional topography. Observations by the author suggest that there is a high probability of finding ice-contact mounds where there are indentations or notches in the North Mountain and South Mountain adjacent to the Annapolis Valley floor. When the glacial ice was melting, pre-existing stream and ice-carved valleys became the natural pathways for water drainage and the development of sediment-laden meltwater channels. Eskers and kame deltas commonly formed at the base of the notches. Today these areas contain large, modern streams. Examples of large sand and gravel deposits that are found at the base of the South Mountain include Windsor Forks, Nictaux Falls, West Paradise and Bridgetown. Less commonly these deposits are observed along the base of the North Mountain (e.g. near Middleton). Although most of these deposits have probably been found, field work combined with an examination of air photos should reveal new deposits in the future. This exploration tool is also applicable to the margins of other highland areas in the province.

Identification and assessment of sand deposits is another significant component of this project. Natural sand is an important commodity in a variety of applications such as concrete, asphalt, masonry sand and traction sand. The Halifax-Dartmouth area, for example, uses hundreds of thousands of tonnes of sand annually. Due to an absence of these materials near Metro, they are hauled long distances from areas in Hants and Kings Counties. The situation is placing severe pressure on this valuable, nonrenewable resource in the study area. The current research will help to better define the resource and draw attention to concerns regarding its future.

Other Industrial Mineral Occurrences

Several new industrial mineral occurrences were recorded as part of this study. Glaciolacustrine clay deposits were identified in several locations in the study area. Lower Carboniferous sandstone, Goldenville Formation quartzite with closely-spaced joints, and some of the columnar-jointed Jurassic basalt may offer potential as dimension stone for local and export markets. Blocky quartzite boulders found in thick, stony till mounds (e.g. Beaver River Till) could possibly be extracted for applications such as drywall fences and landscaping. A recent study initiated by the author and conducted by Coastal BioAgresearch Ltd. (Termeer, 1996) suggests that finely ground zeolitic basalt may act as a soil amendment or conditioner. This may have important implications for farming and the environment in the future. It is unknown if these industrial mineral occurrences and research suggestions have economic potential;

however, they are of interest and will be discussed at length in the final report as possible development opportunities.

Other Data

Although this investigation has focused on the geotechnical aspects of the stone resource in the region, a variety of other data was collected because of its relevance to resource evaluation. This included land-use issues and environmental factors. For example a high-quality aggregate deposit is just data on a map if it can't be developed because of an overlying subdivision, or is found in an area protected by legislation. Due to their porosity and permeability, some of the glacial deposits are important aquifers which should be protected for the future. The recording of abandoned pits may be significant from a subsequent land-use perspective. Depending on the characteristics of the sites, they may have a future use such as trout farming or as an apiary.

Finally, the field study also provided an opportunity to record other geoscientific data that are not connected to the assessment of the resource but may have relevance in the future. The very nature of aggregate extraction means the progressive removal of the materials in pits and quarries, which contain an abundance of geological information. Although the data collected during these site visits is, in effect, a 'snapshot in time and space', the author feels that it is important to document this information before the deposits disappear.

Anticipated Results of Study

The outcome of this research will be a collection of point data, site descriptions and aggregate resource maps in digital format. More than 4000 stations have been documented and approximately 200 samples collected for analysis. Hundreds of photographs taken throughout the region will be digitally scanned and attached to the digital data-base being constructed for this project. A summary report describing the results of the research will be the final phase of the work.

Western HRM Project

The Halifax Regional Municipality (HRM) is the largest aggregate market in Atlantic Canada, consuming more than 3 million tonnes of crushed stone from local quarries annually. The aggregate is used in a wide variety of construction applications including Portland cement concrete, roads, septic fields, back fill and erosion control. Although much of the material is used for residential and commercial purposes, a large component of the stone is used in public works projects such as highways, concrete bridges and underground services. As a result these basic materials are fundamental to the functioning of this urban community.

The region has been extremely fortunate to have local sources of high-quality aggregate. The quality of the materials is important from the perspective of product safety and maximizing the life span for structures such as concrete overpasses and highways. Premature repair or replacement of these expensive structures is extremely costly. The proximity of quarries to markets is equally important, given that transportation costs are the highest component in the delivered price of the stone. Thus the cost and quality of these bulk construction materials are major considerations for public works agencies and the taxpayer who provides the funds for the community's infrastructure.

Although the aggregate industry near Metro is currently thriving, a recent aggregate resource study by DNR (Prime, 2001) concluded that the future is less certain. Concerns centre on the urban sprawl which is taking place in the fringe areas where resource potential still exists. Encroachment by land uses considered incompatible with quarrying (e.g. residential development) is sterilizing the resource land at an accelerating rate. The construction associated with this urban and suburban expansion is also accelerating the consumption of quarry stone. While the pressure on aggregate reserves increases, attempts to open new quarries near Metro have been unsuccessful. Eventually access to the local resource will disappear, leaving the region with expensive, distant choices for obtaining these vital materials.

In an attempt to mitigate this trend the Mineral Resources Branch of NSDNR is re-examining the aggregate potential in the region to determine if new quarry development is possible. The focus of the Western HRM Project is the identification of high-quality stone in strategic locations to the west of Metro (Fig. 1) where impacts to the environment and communities will be minimized. By comparing resource and land-use maps with the property ownership database, an area was determined to have optimal conditions for future aggregate development. This included the quality of the stone, proximity to market, and property ownership that is perceived to be favourable for resource development.

A field study was conducted and samples collected for analysis. Aggregate test results indicate that many of the fine- to medium-grained granitic rocks in the study area exhibit the characteristics of high-quality construction aggregate. In order for a quarry to be successful at this location, DNR proposes the construction of a dedicated access road from the aggregate operation to a nearby primary highway by means of an overpass connector. This would allow a quarry development site potentially as close as 7 km from a sizeable community. This distance would permit the hypothetical operation to be competitive on the western side of the Metro aggregate market. Direct access to a major highway would also reduce trucking through communities. Another major benefit is the land ownership. The land owner has extensive acreage which should permit natural buffers around a quarry and reduce the likelihood of encroachment associated with urban development.

Project Status

Although the results look promising, new resource development in this area will ultimately require the interest and co-operation of public and private stakeholders. A report is in the final stages of review and will be released as soon as possible.

Resource Inquiries are Encouraged

Anyone with questions about any aspect of the aggregate resource is encouraged to contact the author at Department of Natural Resources (902-424-8146). The DNR library also carries a comprehensive assortment of reports, journals, maps and other publications which can be useful in identifying and evaluating aggregate deposits. Finally, there is also a broad range of other geological expertise among the staff at the department which can be accessed to obtain additional information on the geology of the aggregate resource.

References

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